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Awareness and Diagnostic Accuracy of Cauda Equina Syndrome: A Multicenter Study Among Emergency and Primary Care Physicians

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Abstract **Introduction:** Cauda Equina Syndrome (CES) is a neurosurgical emergency characterized by motor and sensory deficits in the lower limbs, pelvic floor and sphincters. Hallmark symptoms include low back pain, saddle anesthesia, bilateral sciatica and bladder dysfunction. Delayed diagnosis and intervention can lead to irreversible neurological damage. This study assessed the diagnostic and management proficiency of emergency medicine and primary healthcare physicians, aiming to identify knowledge and training gaps contributing to CES-related delays. **Methods:** A multicenter cross-sectional study was conducted among 274 physicians in emergency and primary care settings across Saudi Arabia. Participants were interviewed using structured, scenario-based clinical vignettes to evaluate decision-making accuracy in realistic CES presentations. The sample included residents, specialists and consultants from family medicine, general practice and emergency medicine. **Results:** Scenario-level accuracy ranged from 42.0% for recognizing the need for urgent decompression within 48 hours to 63.1% for selecting MRI as the imaging of choice in classic CES. Diagnosis of CES in bilateral sciatica with urinary retention was correct in 60.6% of cases. Physicians with ≤10 years of experience demonstrated significantly higher overall diagnostic accuracy and urgency recognition ($p \leq 0.001$). Residents adhered more closely to recommended management protocols, while specialists exhibited greater diagnostic precision. **Conclusion:** This study revealed substantial gaps in CES knowledge and diagnostic accuracy, particularly among senior physicians. Targeted education and standardized protocols are needed to improve recognition of red flags and ensure timely intervention. Reinforcing awareness of CES and the critical 48-hour surgical window may help prevent irreversible neurological harm.

Key Words Cauda equina Syndrome (CES), Cauda Equina Syndrome Incomplete (CESI), Cauda Equina Syndrome with Retention (CESR), Family Medicine (FM), Emergency Medicine (EM)

INTRODUCTION

Cauda Equina Syndrome (CES) is a rare but serious condition resulting from compression of the lumbosacral nerve roots within the spinal canal below the conus medullaris [1]. It constitutes a neurosurgical emergency, as timely decompression is critical to halt neurological deterioration and potentially restore function [2]. The most frequent etiology is central lumbar disc herniation, particularly at the L4/5 or L5/S1 levels, although other causes include more proximal disc lesions, spinal infections, neoplasms and traumatic injuries [3].

CES often presents non-specifically, delaying diagnosis and worsening outcomes and costs [4]. It may be acute or insidious and is classified as incomplete CES-I (CES Incomplete), with preserved sphincter function or complete with retention CES-R (CES with Retention), defined by painless retention and overflow incontinence [5]. Trigone sensitivity testing aids in distinguishing neurogenic from functional retention [5-7]. Early decompression is essential; CES-I yields superior outcomes, though approximately 70 percent of CES-R cases attain acceptable function [5,8].

There is broad consensus on the importance of prompt CES diagnosis and surgical referral [9,10]. However, its rarity limits high-quality evidence on critical issues, including: (1) Delays in diagnosis and referral, (2) Surgical timing beyond 24-48 hours, (3) Prognostic value of sphincter

and sensory deficits, (4) Unilateral versus bilateral leg signs, (5) Sciatic root involvement and (6) Medico-legal implications [6].

Among these, the medico legal impact of CES is especially significant. It is one of the most frequent sources of litigation in spinal pathology, particularly in primary care and emergency settings. In the United Kingdom, over 200 CES related claims were reported over a five year period, with average payouts ranging from £117,000 to more than £330,000 per case. Individual settlements reached up to two million pounds. Most claims resulted from delayed diagnosis or inadequate early management and nearly half of concluded cases resulted in compensation. Even with timely surgery, many patients suffer permanent dysfunction. When diagnosis is missed or delayed, incomplete syndromes may progress while under medical care, leading to avoidable disability and substantial legal exposure [5,6].

Cauda Equina Syndrome (CES) shares features with other lumbosacral disorders, often delaying diagnosis [3,2,12]. Hallmarks include bowel, bladder or sexual dysfunction and saddle anesthesia, though delayed onset is common and linked to worse outcomes [3,4]. Additional signs-low back pain, radiculopathy, limb weakness, sensory loss and hyporeflexia-are frequent [11,12]. Diagnosis requires detailed history and neurological exam, considering infectious or neoplastic causes [11-14].

Among essential clinical assessments, sacral sensory examination serves as a rapid and specific tool for detecting CES, yet it is often underperformed in initial evaluations, contributing to diagnostic delays and suboptimal outcomes [4,15-19].

Magnetic Resonance Imaging (MRI) is the diagnostic modality of choice when CES is suspected [20]. Timely decompression-ideally before incontinence onset-may prevent irreversible complications, including bladder and bowel dysfunction, saddle anesthesia, neuropathic pain and paralysis [6,8]. Delays, especially in non-specialist settings such as primary care and emergency departments, remain common; a general practitioner may encounter CES only once in a career [7]. Surgery aims to relieve compression and address underlying causes such as infection or coagulopathy [8,21-23].

Adjuncts may include antibiotics or anticoagulation reversal, when indicated [3,11]. Given the unpredictable course of neurological decline, prompt intervention is critical [6,14]. However, retrospective and heterogeneous data limit evidence strength, complicating guideline development [5,8,24,25].

This study assessed the diagnostic and management proficiency of emergency and primary care physicians regarding Cauda Equina Syndrome (CES), given its variable presentation and diagnostic challenges [15]. These clinicians often serve as first-contact providers, making early recognition critical. To our knowledge, this is the first multicenter study in the region to evaluate physicians' knowledge of cauda equina syndrome using scenario-based assessment across clinical ranks and specialties, offering a structured perspective on decision making in frontline care. Identifying knowledge and practice gaps may inform targeted educational strategies to improve early detection and intervention.

METHODS

Study Design: A cross-sectional observational study was conducted in the City of Taif, Saudi Arabia, from October 24 to December 24, 2024. Participants were recruited using a convenience sampling approach from public and private hospitals across the region. Eligibility included practicing Family and Emergency Medicine physicians of any clinical rank who were available during scheduled site visits and consented to participate. A total of 274 physicians voluntarily completed a structured questionnaire. Data were collected through structured interviews during working hours by members of the research team. Informed consent was obtained from all participants, with assurances of confidentiality and voluntary participation.

Questionnaire Design: The questionnaire comprised two main sections:

- **Demographics:** Included specialty (Family or Emergency Medicine), years of experience, professional rank (Resident, Specialist, Consultant) and hospital type (Primary Healthcare Center or Emergency Department)
- **Scenario-Based Questions:** This section contained six clinical scenarios encompassing eight multiple-choice questions (MCQs) designed to assess diagnostic and management proficiency in Cauda Equina Syndrome (CES). The scenarios reflected a spectrum of diagnostic challenges outlined in published CES guidelines [1,11,15,26], including variation in symptom onset, overlap with other neurological conditions and decisions regarding imaging and surgical timing. Each MCQ had a single best answer consistent with current guideline recommendations and all distractor options were plausible but incorrect. Difficulty was intentionally varied to include both straightforward and complex presentations, simulating real-world diagnostic uncertainty in emergency and primary care

Examples included a 56-year-old patient with acute back pain, saddle anesthesia and bladder/bowel dysfunction requiring identification of the next diagnostic step and a 38-year-old patient with bilateral sciatica and urinary retention requiring differentiation between CES and Guillain Barré Syndrome or peripheral neuropathy.

Scenario content was generated using artificial intelligence tools, including ChatGPT (OpenAI, August 2023 version) [27] and refined by a panel of three orthopedic surgeons and one neurosurgeon. The panel independently reviewed each case for accuracy, relevance and consistency. Revisions were made based on their feedback and the final set was approved by consensus. Although formal psychometric validation was not conducted, the questionnaire was pretested with ten physicians to ensure clarity, internal consistency and content validity.

Scoring and Knowledge Classification

Each participant's CES knowledge score was calculated based on the total number of correct responses across the eight scenario-based questions (maximum score: 8). By expert consensus among the study investigators, a threshold of five or more correct answers was defined as indicative of good knowledge. Participants who scored fewer than five correct answers were classified as having poor knowledge. This binary classification was used for subgroup comparisons and statistical analysis.

Ethics

The study received ethical approval from the Research Ethics Committee at Taif University, Saudi Arabia (Approval Date: 29-09-2024; IRB Number: 46-042).

Statistics

Data were analyzed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY, USA). Categorical variables were presented as frequencies and percentages, while continuous variables were summarized as means and standard deviations (SD). Comparative analyses were performed using the chi-square test where applicable. A p-value <0.05 was considered statistically significant.

RESULTS

Of the 274 physicians included in the study, 40.5% specialized in Family Medicine (FM), 30.3% were General Practitioners (GP) and 29.2% specialized in Emergency Medicine (EM). Among them, 55.1% were residents and 54.4% had ≤10 years of work experience, with a mean duration of 10.54±7.27 years. Regarding the workplace setting, 52.2% were employed in emergency departments across Ministry of Health (MOH), military, private or National Guard hospitals, while 47.8% were based in primary healthcare centers (Table 1).

When presented with six CES case scenarios, diagnostic accuracy varied (Table 2). The highest performance was for diagnosing CES in bilateral sciatica with urinary retention (Case 2, 60.6%, 95% CI 54.8-66.4) and selecting MRI as the imaging of choice (Case 2b, 63.1%, 95% CI 57.4-68.8). The lowest was for recognising the need for surgical decompression within 48 hours (Case 6, 42.0%, 95% CI 36.2-47.8) and identifying insidious CES (Case 3, 43.8%, 95% CI 37.9-49.7). Other challenges included recognising the classic triad of CES (Case 4, 49.3%) and rejecting spasticity as a typical symptom (Case 5b, 53.3%). Specialty analysis (Table 3) showed emergency medicine physicians were more likely to request emergency MRI for classic CES (68.7% vs 45.0% in family medicine, p = 0.011) and recognise chronic CES (53.0% vs ~40%), whereas family medicine and general practitioners were more accurate in identifying a herniated disc on MRI (61.3% each vs 49.4%, p = 0.009). No other significant specialty differences were found.

The variation in performance across scenarios (42.0%-63.1%) was consistent with the intended balance of difficulty, with more complex or atypical presentations yielding lower accuracy rates.

Table 1: Demographic and professional characteristics of the physician sample (N = 274)

Variable	No. (%)
Specialty	
EM	80 (29.2)
FM	111 (40.5)
GP	83 (30.3)
Position	
Consultant	60 (21.9)
Specialist	63 (23)
Resident	151 (55.1)
Work experience (years)	
0-10	149 (54.4)
11-20	103 (37.6)
21-30	19 (6.9)
31-40	3 (1.1)
Work experience (years) (Mean±SD)	10.54±7.27
Hospital type	
Emergency department in (MOH, Military Hospitals, Private, National Guard Hospitals)	143 (52.2)
Primary healthcare center	131 (47.8)

FM: Family Medicine, GP: General Practitioner, EM: Emergency Medicine, MOH: Ministry of Health

Table 2: Diagnostic Accuracy and Confidence Intervals for CES Case Scenarios (N = 274)

Scenario	Correct (%)	N	95% CI
Case 1: Emergency MRI for classic CES symptoms	58.0	274	52.2-63.8
Case 2: Diagnosis of CES (bilateral sciatica + retention)	60.6	274	54.8-66.4
Case 2b: MRI as imaging of choice	63.1	274	57.4-68.8
Case 3: Recognition of insidious CES presentation	43.8	274	37.9-49.7
Case 4: Recognition of classic triad	49.3	274	43.4-55.2
Case 5a: Correct MRI finding (herniated disc L1-L5)	57.7	274	51.9-63.5
Case 5b: Spasticity correctly rejected as CES symptom	53.3	274	47.4-59.2
Case 6: Urgent surgical decompression within 48h	42.0	274	36.2-47.8

CES: Cauda Equina Syndrome, MRI: Magnetic Resonance Imaging

Table 3: Relationship Between Physicians' Specialty and Their Responses to Cauda Equina Syndrome (CES) Case Scenarios (N = 274)

Scenario	Correct Response-FM (%)	Correct Response-GP (%)	Correct Response-EM (%)	p-value
Case 1: Emergency MRI for classic CES symptoms	45.0	59.5	68.7	0.011
Case 2: Diagnosis of CES (bilateral sciatica+retention)	57.5	60.4	63.9	0.903
Case 2b: MRI as imaging of choice	53.8	64.9	69.9	0.419
Case 3: Recognition of insidious CES presentation	40.0	39.6	53.0	0.592
Case 4: Recognition of classic triad	42.5	52.3	51.8	0.784
Case 5a: Correct MRI finding (herniated disc L1-L5)	61.3	61.3	49.4	0.009
Case 5b: Spasticity correctly rejected as CES symptom	51.2	51.4	57.8	0.143
Case 6: Urgent surgical decompression within 48h	32.5	50.5	39.8	8

CES: Cauda Equina Syndrome, MRI: Magnetic Resonance Imaging, FM: Family Medicine, GP: General Practioner, EM: Emergency Medicine

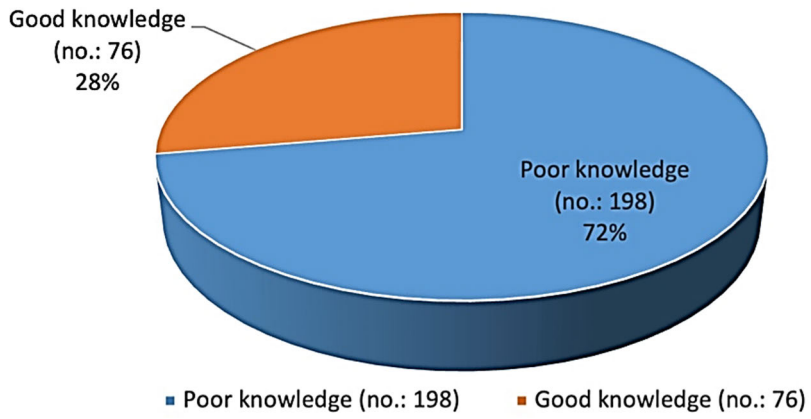

Figure 1: Distribution of CES Knowledge Score among Physician

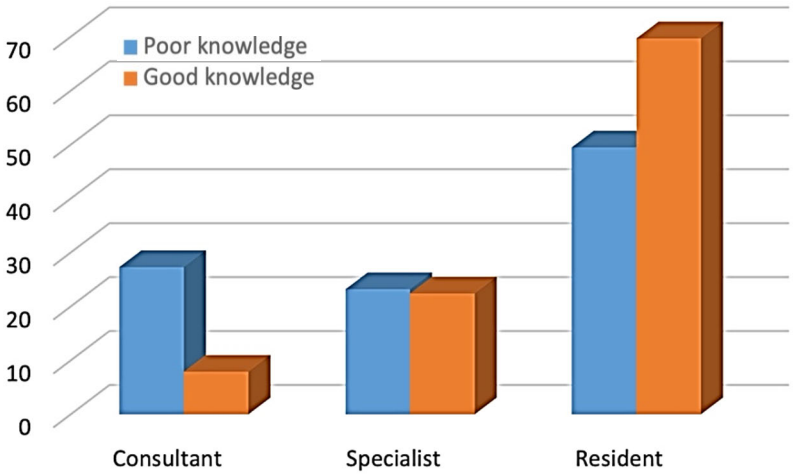

Figure 2: CES Knowledge of Professional Rank

The mean CES knowledge score was 4.27±1.97 (out of 8). Only 27.7% (95% CI: 22.5-33.4) achieved a score indicating good knowledge (≥5), while 72.3% scored below this threshold (Figure 1).

Regarding rank, residents had the highest proportion of good knowledge (69.7%), followed by specialists (22.4%) and consultants (7.9%), as illustrated in Figure 2 ($p = 0.001$). Similarly, 75% of physicians with ≤10 years of experience demonstrated good CES knowledge, compared to 21.1% among those with 11-20 years and only 3.9% among those with >20 years ($p<0.001$; Figure 3).

When comparing specialties, Emergency Medicine physicians consistently outperformed Primary Care physicians (merged Family Medicine and General Practitioners) across multiple scenarios. In Case 1, EM physicians more often chose MRI as the first step (68.7% vs. 53.2%, $p = 0.012$). They also performed better in Case 3 (recognizing chronic CES: 53.0% vs. 39.8%, $p = 0.028$) and Case 6 (recognizing need for surgical urgency: 39.8% vs. 43.8%, $p = 0.047$). Conversely, both groups had similarly low recognition in Case 4 (triad recognition: EM 51.8%, Primary Care 48.0%, $p = 0.341$), indicating

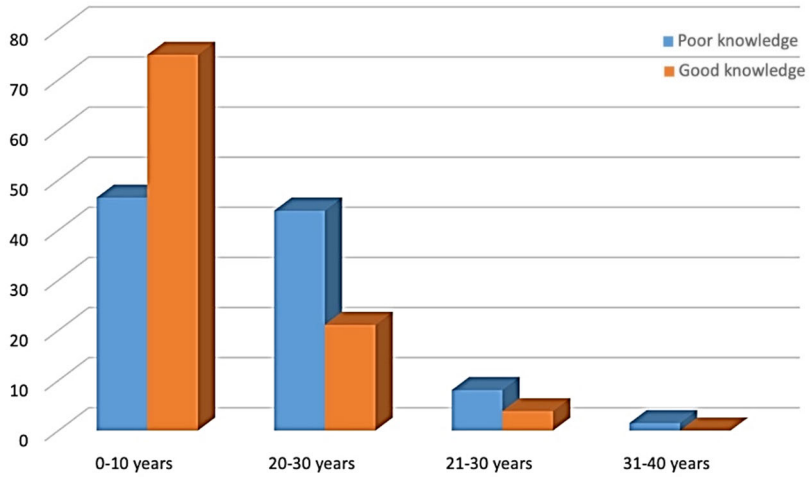

Figure 3: CES Knowledge Level by Years of Clinical Experience

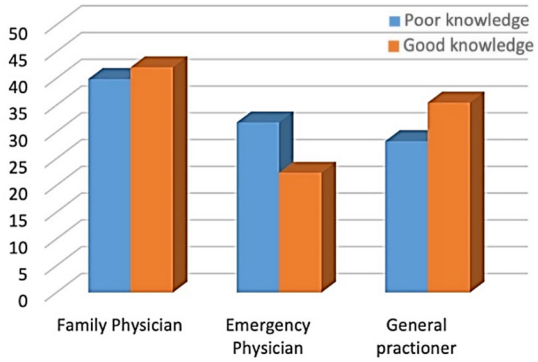

Figure 4: CES Knowledge Level by Specialty

widespread underperformance in this critical scenario (Table 3, CES Case Scenario Responses by Specialty).

As shown in Figure 4, a higher proportion of Emergency Medicine physicians demonstrated good knowledge (defined as a score ≥5) compared to Primary Care physicians (63.9% vs. 44.1%, p = 0.013).

Physicians working in primary healthcare centers more frequently selected MRI in classic CES presentations (64.9% vs. 51.7%, p = 0.022), possibly reflecting greater protocol adherence in structured triage settings.

As shown in Figure 5., there was a statistically significant inverse relationship (Spearman's r = -0.34, p<0.001), indicating that CES knowledge declined with increasing years of experience. This trend persisted across all professional ranks and specialties, emphasizing the need for updated training even among senior physicians.

DISCUSSION

Cauda Equina Syndrome (CES) is a rare but critical neurosurgical emergency, where diagnostic and referral delays can result in irreversible neurological sequelae such as incontinence, sexual dysfunction and lower limb paralysis [6,8]. This multicenter study assessed the diagnostic accuracy and management proficiency of Family Medicine (FM) and Emergency Medicine (EM) physicians across multiple healthcare settings. Key findings revealed substantial gaps in CES recognition, urgency prioritization and appropriate imaging selection, particularly among senior physicians and consultants.

The observed inverse correlation between knowledge scores and years of experience (r = -0.34, p<0.001) suggests that exposure to CES during early training, coupled with more recent academic instruction, likely contributes to better recognition. These findings highlight the need to reinforce CES-related education through targeted continuing medical education (CME), particularly for consultants and mid-career physicians who may rely more heavily on pattern recognition and outdated algorithms [3,4,11,12]. The observed inverse correlation between knowledge scores and years of experience (r = -0.34, p<0.001) suggests that exposure to CES during early training, coupled with more recent academic instruction, likely contributes to better recognition. These findings highlight the need to reinforce CES-related education through targeted Continuing Medical Education (CME), particularly for consultants and mid-career physicians who may rely more heavily on pattern recognition and outdated algorithms.

In one key scenario, 60.6% correctly identified CES, while 22.6% misclassified it as Guillain Barré Syndrome (GBS), a confusion likely driven by overlapping signs such as hyporeflexia, bilateral lower limb weakness and sensory deficits [28]. While both conditions share these features, CES typically presents with bladder or bowel dysfunction and saddle anesthesia, which are absent in GBS. However, reports exist of GBS cases showing urinary incontinence or retention and magnetic resonance imaging evidence of gadolinium enhancement of the cauda equina and lumbar nerve roots, reflecting proximal nerve inflammation. Similar enhancement has also been described in chronic inflammatory demyelinating polyneuropathy, further complicating clinical differentiation. Incorporating targeted training, including simulation cases that directly contrast CES and GBS, alongside awareness of such imaging overlaps, could improve diagnostic accuracy and reduce misclassification [29].

This pattern of misdiagnosis was more common among consultants and physicians with over 20 years of experience, possibly reflecting less recent exposure to CES presentations and greater reliance on familiar neuropathic differentials such as GBS [26,30]. Although there was no statistically significant association between diagnostic accuracy and physician rank ($p = 0.282$), residents generally performed better, possibly reflecting the recency of their training and greater familiarity with updated diagnostic protocols.

Timely decompression within 48 hours is a critical determinant of functional recovery in CES, particularly for bladder and bowel function [31,32]. In this study, only 42% of respondents correctly identified the need for urgent surgical intervention within this window, with urgency recognition declining markedly with increasing years of experience. Among physicians with 0-5 years of experience, 63% correctly identified the surgical timeline, compared to only 25% of those with 21-30 years of experience. This finding warrants attention because surgical decompression within 48 hours is strongly associated with improved neurological outcomes in CES [32,33]. Such delays also contribute to the medico legal exposure and long term healthcare burden previously outlined in the Introduction [5,6,31].

Specialists and residents were more likely to select MRI as the initial investigation in classic CES scenarios, consistent with evidence-based recommendations [20,34]. However, a significant portion of consultants opted for inappropriate management such as pain relief and scheduled follow-up (23.3%) or physiotherapy referral (26.7%), indicating a tendency to default to mechanical back pain algorithms even in the presence of red flags [15].

Recognition of the insidious presentation of CES was limited. Only 43.8% of respondents correctly identified gradual-onset features, with consultants and specialists frequently selecting acute motor symptoms or L5-S1 pathology as more likely. The tendency to overemphasize familiar spinal conditions such as degenerative spondylolisthesis likely contributed to this error. [37,38] Additionally, "spasticity in the lower limbs," an Upper Motor Neuron (UMN) sign, was frequently misidentified as typical of CES, reflecting confusion between CES and spinal cord pathologies such as multiple sclerosis [35].

When asked to identify atypical symptoms, such as spasticity, 55.6% responded correctly; however, 16.8% erroneously labeled "urinary retention" as atypical-a fundamental misconception, especially among consultants (23.3%) [3,4]. These results indicate that features such as urinary retention, saddle anesthesia and the absence of spasticity were frequently misunderstood or misclassified, particularly by senior physicians [36].

Subgroup analysis confirmed that younger physicians and those with fewer years of experience more accurately diagnosed CES, selected appropriate imaging and recognized its urgency. Interestingly, physicians in primary healthcare centers (PHCs) more often initiated MRI compared to those in hospital-based emergency departments, possibly reflecting greater adherence to referral protocols in structured triage settings ($p = 0.022$).

To our knowledge, no prior studies in the UK, US, Australia or elsewhere have directly assessed physicians' CES knowledge using a comparable scenario-based approach. Most international reports have instead focused on red-flag diagnostic accuracy or referral protocols rather than structured knowledge assessments. Our findings thus offer a valuable baseline for future cross-national comparison.

A significant inverse correlation between knowledge scores and years of clinical experience ($r = -0.34$, $p<0.001$) suggests a concerning erosion of spinal emergency knowledge over time. This underscores the need to integrate CES-focused content into both undergraduate curricula and postgraduate CME, particularly for consultants and mid-career physicians who may rely more heavily on heuristics and chronic pathology patterns. Emphasis should be placed on timely MRI referral, differentiation from GBS and upper motor neuron disorders and recognition of both acute and insidious CES presentations. Simulation-based learning, scenario-driven diagnostic exercises and diagnostic checklists could significantly improve recognition under pressure. Incorporating red flag alert systems into electronic medical records may further prompt timely referral and imaging in at-risk patients. Red flags for potential CES tend to be more specific than sensitive; therefore, their presence should prompt immediate diagnostic evaluation [37]. Standardizing continuous educational content and management protocols across healthcare settings will likely improve diagnostic accuracy, reduce delays in surgical intervention and ultimately improve patient outcomes [38,39].

This study's scenario based approach offers valuable insight into clinical reasoning under diagnostic uncertainty and is one of the few multicenter investigations comparing CES knowledge across specialties, ranks and healthcare settings. Nevertheless, the use of hypothetical case scenarios may not fully capture real time clinical decision making under pressure and may overestimate performance. The cross sectional design captures a single point in time and cannot establish causality. Convenience sampling and voluntary participation may have introduced selection bias and unequal representation of ranks or institutions may further limit generalizability. The exclusion of specialties such as neurology and orthopedics also restricts broader comparative interpretation. Missing data on prior CES case exposure, CME participation and institutional protocol availability, along with the absence of a formal sample size calculation or multivariate adjustment, may have introduced unmeasured confounding.

Although odds ratios could provide effect size estimates, we opted not to report them due to the summarized nature of our frequency level data. Without access to individual level data, such estimates risk being misleading; chi square analysis was therefore used as the more appropriate method.

CONCLUSIONS

In conclusion, this multicenter study identified significant knowledge gaps and diagnostic variability in the evaluation and management of Cauda Equina Syndrome (CES) among frontline physicians, particularly among consultants and those with greater clinical experience. By employing a scenario-based approach, the study met its objective of assessing real-world clinical reasoning across specialties and career stages, revealing specific deficiencies in recognizing red flag symptoms and initiating timely intervention. These findings highlight critical training gaps that place patients at risk for delayed diagnosis and irreversible neurological harm. Addressing these shortcomings requires integrating CES-specific content into continuing medical education, with emphasis on early recognition and urgent referral protocols. Simulation-based training and standardized diagnostic pathways should be prioritized in emergency and primary care settings. Targeted reinforcement for senior physicians may also mitigate the observed decline in diagnostic proficiency over time. Future research should evaluate the impact of these interventions on clinical practice and patient safety outcomes.

Acknowledgement

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Conflicts of Interest

The authors declare no conflicts of interest, financial or nonfinancial, related to the subject matter of this manuscript. No financial support, consultancies, honoraria, stock ownership, expert testimony, grants, patents or royalties have been received in the past three years. Additionally, the authors report no personal, political or professional relationships that could have influenced the preparation or content of this work.

Ethical Statement

The study received ethical approval from the Research Ethics Committee at Taif University, Saudi Arabia (Approval Date: 29 September 2024; IRB Number: 46-042). Written informed consent was obtained from all participants prior to their inclusion. Participation was entirely voluntary, with the option to decline or withdraw at any stage without consequence to their professional standing or employment. Data were collected and analyzed anonymously, with no identifying information recorded, ensuring confidentiality throughout.

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